SYNOPSIS OF RESEARCH PROJECT

ON

EFFECT OF PLANT GROWTH REGULATORS AND FERTILIZER LEVELS ON GROWTH, YIELD AND QUALITY OF SUMMER PEARL MILLET

UNDER THE GUIDANCE OF

Dr. V. B. BHALU
ASSOCIATE PROFESSOR
DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
JUNAGADH AGRICULTURAL UNIVERSITY
JUNAGADH

SUBMITTED BY

MANOJ KUMAR MEENA

(Registration No.: 1010125043)

DEGREE FOR

Ph.D. in Agronomy

SUBMITTED TO

DIRECTOR OF RESEARCH
AND DEAN, P. G. STUDIES
JUNAGADH AGRICULTURAL UNIVERSITY
JUNAGADH

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
JUNAGADH AGRICULTURAL UNIVERSITY
JUNAGADH-362001

Date of Submission: /03/2026

Current Semester: Second

SYNOPSIS OF RESEARCH PROJECT

1.	**Name of Student**	:	MANOJ KUMAR MEENA
2.	**Registration No.**	:	1010125043
3.	**Faculty**	:	Agriculture
4.	**Name of Degree**	:	Ph.D.
5.	**Major Subject**	:	Agronomy
6.	**Minor Subject**	:	Soil Science
7.	**Name of Major Guide**	:	Dr. V. B. Bhalu Associate Professor Department of Agronomy College of Agriculture JAU, Junagadh
8.	**Title of Research Project**	:	**EFFECT OF PLANT GROWTH REGULATORS AND FERTILIZER LEVELS ON GROWTH, YIELD AND QUALITY OF SUMMER PEARL MILLET**

9. Introduction

Pearl millet (*Pennisetum glaucum* L.) is an important millet crop and grown for both food supply and fodder material purpose. Pearl millet popularly known as bajra belongs to the family *Poaceae* or *Gramineae*. It grows on sandy soils having poor fertility and its drought escaping character has made it a popular crop of drought prone areas. The average nutrient constituents of the edible portion of the seed contains 67% carbohydrate, 12.4% moisture, 11.6% protein, 3.5% fat, 1.5 to 3.0% fiber and 2.7% minerals (Sharma and Burark, 2015). Grains constitute an important cattle/poultry feed. Green fodder is used either as such or preserved as hay or silage which has proved extremely useful in dry areas.

In terms of area and importance, pearl millet is the fourth leading food crop in India after rice, wheat and maize. It also occupies an important place in the daily diet of many classes of people in India. During 2024-25, pearl millet was cultivated in 7.36 million hectares with a production of 10.80 million tonnes and productivity of 1468 kg/ha (Anon., 2025). The major pearl millet cultivated states are Rajasthan, Uttar Pradesh, Gujarat, Haryana and Maharashtra contributing to 90 per cent of total production in the nation. Rajasthan accounts for the largest share of pearl millet production in India, contributing about 45%, followed by Uttar Pradesh (19%), Haryana and Gujarat (9% each), Maharashtra

(6%) and Tamil Nadu (2%). In India, pearl millet is predominantly cultivated during the rainy (*kharif*) season. However, it is also grown as a summer crop from February to May in certain regions of Gujarat, Rajasthan and Uttar Pradesh where reliable irrigation facilities are available. The major pearl millet cultivated districts in Gujarat are Banaskantha, Bhavnagar, Surendranagar, Anand, Junagadh, Jamnagar, Rajkot, Amreli and Kutch.

Nitrogen is an indispensable nutrient for plant growth and development. It is a critical component of chlorophyll, which helps plants absorb sunlight for photosynthesis. It stimulates cell division and elongation, leading to healthy stem and root growth. Its application can increase plant height and biomass production.

Phosphorus is vital for the development of robust roots and seeds in plants. It also contributes greatly in DNA replication, enabling the formation of cell walls and facilitating the entire reproductive process. In contrast, nitrogen is essential for the growth of plant leaves and stems. It is utilized in the synthesis of amino acids, the building blocks of plant proteins, contributing significantly to overall plant growth and development.

PGRs are organic substances, distinct from nutrients, that influence physiological activities in plants. Often referred to as bio stimulants or bio inhibitors, they function within plant cells by either promoting or suppressing the activity of specific enzymes or enzyme systems, thereby controlling metabolic processes. These compounds are typically effective even at very low concentrations.

PGRs, may be able to increase crop yield in response to environmental stress. Chemical compounds known as growth regulators can change how a grain grows and develops, resulting in higher yield, better grain quality or easier harvesting. The growth parameters of pearl millet were greatly affected by the application of plant growth regulators and fertilizer levels. The external application of NAA to improve growth and yield in a range of harsh conditions, such as heavy metal toxicity, drought, salt and high temperature. Additionally, they participate in highly significant agronomic developmental processes such seed germination, leaf angle, blooming duration and grain yield.

NAA is a synthetic auxin that plays a critical role in regulating growth and developmental processes in pearl millet (*Pennisetum glaucum*). NAA modulates cell elongation and division, particularly in root meristematic tissues, resulting in enhanced initiation and proliferation of both primary and lateral roots. This improved root system architecture facilitates efficient acquisition of water and mineral nutrients from deeper soil profiles, which is especially advantageous under moisture-limited and nutrient-deficient conditions typical of arid and semi-arid environments. In addition to its influence on root

development, NAA positively affects reproductive growth by improving floral differentiation, sink–source relationships and assimilate partitioning towards developing grains. External application of NAA has also been reported to enhance physiological efficiency by improving photosynthetic capacity, chlorophyll stability and overall metabolic activity, thereby contributing to superior growth performance and grain yield in pearl millet (Mourya and Singh, 2022).

Salicylic acid, a phenolic molecule regulates various physiological processes including germination, ion absorption, photosynthesis, plant development and has the capacity to prevent the incidence of systemic diseases in plants (Vicente and Plasencia 2011; Bekele *et al.,* 2021). It also acts as antioxidant which plays important role in plant response to abiotic stress (Janda *et al.* 2017). External application of salicylic acid to different crops helps in inducing defense proteins which plays vital role in viral, bacterial, fungal pathogens and insect pest resistance mechanisms by interfering with their digestive systems (Bekele *et al.,* 2021).

10. Practical Utility of the Research Project

Pearl millet, with its ability to thrive in harsh climates, performs a crucial function in mitigating the impact of climate change. Its deep root system allows it to endure water scarcity, making it a resilient crop in arid regions. Moreover, its nutritional richness, especially in iron and zinc, addresses malnutrition and hidden hunger, enhancing the overall health of communities. Additionally, its cultivation not only ensures food security but also boosts income for farmers, making it a crucial asset for sustainable agriculture in challenging environments.

NAA is a synthetic plant growth regulator classified under the auxin group. It is critical in regulating plant physiological processes by promoting cell division and elongation, enhancing photosynthetic activity and stimulating RNA synthesis. NAA is particularly effective in inducing adventitious root formation, which improves the plant's capacity for nutrient and water uptake. Through these physiological and biochemical modifications, NAA contributes to improved crop growth, yield and quality of grain.

Salicylic acid (SA) is an important plant signaling molecule involved in promoting seed germination, regulating plant growth and inducing flowering. It plays important role in modulating plant responses to both abiotic and biotic stresses. Salicylic acid functions as an integral component of multiple signaling pathways and interacts with other plant hormones to coordinate defense mechanisms and stress tolerance.

In light of the above-mentioned facts, a field experiment entitled "Effect of plant growth regulators and fertilizer levels on growth, yield and quality of summer pearl millet" is proposed to conduct at Instructional farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during summer of 2026 and 2027 with the following objectives.

11. Objectives

1. To assess the effect of foliar application of plant growth regulators and fertilizer levels on growth, yield and quality of summer pearl millet.
2. To evaluate the effect of foliar application of plant growth regulators and fertilizer levels on nutrient dynamics.
3. To work out the economic feasibility of different treatments.

12. Review of Literature

12.1 Effect of NPK fertilizers

12.1.1 Growth attributes

Rathore *et al.* (2006) studied that application of 60 kg/ha nitrogen and 40 kg/ha phosphorus significantly improves the growth attributing characters *viz.,* plant height, dry matter accumulation/plant and total tillers/meter row length in pearl millet over control.

Parihar *et al.* (2009) demonstrated that application of 100% recommended dose of fertilizer recorded significantly taller plant height over control and 50% RDF in pearl millet.

Chouhan *et al.* (2015) concluded that plant height (178.47 cm), leaf area index (2.51) and number of effective tillers/plant (5.03) were significantly higher with 125% RDN (RDF: 120-60-00 kg/ha NPK) than with 75% RDN in pearl millet during summer on black cotton soils of Navsari, Gujarat.

Patil *et al.* (2015) conducted a field investigation at Kolhapur to study the consequence of different levels of fertilizers on growth and yield of finger millet. The implementation of recommended dose of fertilizers (60:30:00 kg/ha NPK) in briquette from resulted in significantly improved growth parameters including plant height, number of functional leaves/plant, number of tillers/hill, leaf area/plant and dry matter production/plant.

Divyashree *et al.* (2018) asserted that application of 30:20:10 kg/ha NPK culminated in taller plant height of little millet during *kharif* on sandy loam soils of Shivamogga, Karnataka.

Jakhar *et al.* (2018) illustrated that development crediting characters like plant tallness, dry matter production at 60 days after sowing, total no. of tillers and chlorophyll content of leaves of pearl millet were higher with the use of 100% RDF over the control and remaining treatment combinations.

Singh *et al.* (2018) observed that application of 100% RDF (50:30:15 kg/ha NPK) significantly enhance the plant height, tillers/meter row length and dry matter production of pearl millet as compared to the other treatments.

Verma *et al.* (2018) explained that application of 50% RDF (80:40:30 kg/ha NPK) observed significantly higher growth attributes of pearl millet over control.

Thesiya *et al.* (2019) recorded maximum plant height of little millet with application of 100% RDF (40:20:00 kg/ha) compared to the other lower levels (75% RDF and 50% RDF) tried during *kharif* on clay soil of Waghai, Gujarat.

Application of 40:40:20 kg/ha NPK to little millet resulted in significantly taller plants on sandy loam soils of Perumallapalle, Andhra Pradesh during *kharif* (Sarala *et al.* 2020).

12.1.2 Yield attributes and yield

Parihar *et al.* (2009) performed a trial at IARI, New Delhi and observed that use of 100% RDF significantly improved total no. of tillers/meter row length, ear head/meter row length, grain and biological yield of pearl millet over control and other treatment combinations. In pearl millet, direct use of 100% RDF (60+17.6 kg N and P/ha) markedly enhanced grain yield typically by 33.4 and 12.3% over control and 50% RDF, respectively.

Khambalkar *et al.* (2012) conducted a trail at Gwalior, M.P. and noted that 100% NPK (40:20:20 kg/ha) significantly increased straw and grain yield of pearl millet over control and other treatment combinations.

Yadav and Yadav (2013) noticed that the maximum length of the panicle when the barnyard millet was fertilized with 100% RDF (40:20:20 kg/ha NPK) compared to the rest of the levels tried i.e. 75% RDF & 50% RDF on silty clay loam soils of Ranichauri, Uttarakhand.

Kumar *et al.* (2015) implemented a field trail at Agricultural Research Farm, Agra, U.P., furthermore, result showed that use of 100% N, 100% NP and 100% NPK essentially improved ear head length, number of ear head/meter row length, weight of grains/ear head and 1,000 grain weight of pearl millet over absolute control.

Reddy *et al.* (2016) discovered that the grain and stover yield of pearl millet improved significantly with the application of 100:30:40 kg/ha NPK during *kharif* on sandy loam soils in Tirupati, Andhra Pradesh, compared to the control.

Jakhar *et al.* (2018) documented that application of 100% RDF significantly improved the yield parameters like no. of effective tillers/plant, length and girth of ear head, grain weight/ear head and 1,000 grain weight of pearl millet over other treatments, however it was at par with 100% RDF and 50% RDF.

Singh *et al.* (2018) at IARI, New Delhi registered that application of 100% RDF recorded higher yield attributes as compared with the control. The application of 100% RDF (50:30:15 kg/ha NPK) also recorded significantly higher grain and stover yield of pearl millet over control and other treatment combinations.

Verma *et al.* (2018) reported that higher yield parameters of pearl millet due to application of 50% RDF followed by other treatments and control. INM practices recorded significantly higher grain, stover and biomass yield followed by other treatment combinations. The integrated nutrient management practices increased grain, straw and biological yield of pearl millet with the tune of 75, 46 and 53% over control. The highest harvest index (26.3%) was fetched with application of 50% RDF followed by other treatment combinations.

Harika *et al.* (2019) studies have indicated that the application of 100% RDF (40:20:20 kg/ha NPK) resulted in higher number of panicles, which was comparable with the application of 75% RDF + 2 t FYM + *Azospirillum* @ 5 kg/ha in finger millet on sandy loam soils of Gajapati, Odisha.

Kumar *et al.* (2019) observed that maximum grain yield with the use of 100% RDF in finger millet on clay loam soils of Garhwal, Uttarakhand.

During *kharif,* on medium black soils of Raichur, Karnataka higher grain yield of foxtail millet was recorded with application of 100% RDF (30:15:15 kg/ha NPK) compared to75% RDF (Mubeena *et al*. 2019).

Thesiya *et al.* (2019) observed that higher number of panicles in little millet with the use of 100% RDF, which was at par with 75% RDN through chemical fertilizer + 25% RDN through vermicompost on clayey soils of Navsari, Gujarat.

Ramya *et al.* (2020) conducted an field study at Bagusala Farm to study the effect of biofertilizer *Azospirillum* and graded levels of chemical fertilizer on growth and yield of finger millet. The results of research clearly indicated that application of 100% RDF was beneficial for increasing straw yield of finger millet.

12.1.3 Quality

Jat *et al.* (2002) observed that 60 and 90 kg/ha N application statistically improved the nitrogen content in grain and protein content over control and N application 30 kg/ha. The concentration of nitrogen in stover and its total uptake was maximized of 90 kg/ha use of nitrogen in pearl millet.

An experiment using by Azam *et al.* (2010) on fodder sorghum during the summer season of 2007-09 at Fodder Research Institute, Sargodha, Pakistan. They reported that higher crude fat and crude protein were achieved through the use of 80:50:25 kg/ha NPK.

An experiment using by Deshmukh *et al.* (2019) at Dr. PDKV, Akola during *kharif* season 2014-2015 on pearl millet. They reported that the higher crude protein was obtained with the application of RDF (60:30:00) + K_2O/ha.

12.1.4 Nutrient content and uptake

Raj and Sangwan (2003) completed an experiment under dry land conditions at Hisar, Haryana and tracked down that content and uptake of nitrogen in pearl millet was significantly enhance due to application of 50% RDF over control and other treatment combinations.

Rathore *et al.* (2006) recorded through the use of 100% RDF significantly higher uptake of nutrient N and P_2O_5 of pearl millet over control and rest treatment combinations.

Jat *et al.* (2014) administered a field experiment at Udaipur and revealed that application of 100% NPK significantly enhanced N, P and K content and uptake by sorghum over control and rest of the treatment combinations.

Kumar *et al.* (2014) completed a field investigation at Agricultural Research Farm, Agra, U.P. and found that application of 100% N, 100% NP and 100% NPK significantly increased total N, P_2O_5, and K_2O uptake by pearl millet over control.

Maximum nitrogen uptake by foxtail millet was noticed through the application of 100% RDF (30:15:15 kg/ha NPK) on medium black soils of Raichur, Karnataka during *kharif* (Mubeena *et al.* 2019).

12.1.5 Economics

Reddy *et al.* (2016) conducted an investigation on pearl millet during the *kharif* season at S. V. Agricultural Farm, Tirupati. They found that the 100:30:20 kg/ha NPK gave maximum benefit cost ratio (3.16).

An experiment using by Sagar *et al.* (2017) during *kharif* at Allahabad School of Agriculture, SHUATS, Allahabad (Uttar Pradesh) on pearl millet. They reported that

highest net return and benefit: cost ratio (BCR) recorded with the application of 120:80:60 kg/ha NPK.

Harika *et al.* (2019) documented that application of 100% RDF (40:20:20 kg/ha NPK) recorded higher gross returns, net returns and B:C ratio, which was comparable with application of 75% RDF + 2 t FYM + *Azospirillum* @ 5 kg/ha in finger millet on sandy loam soils of Gajapati, Odisha.

Kumar *et al.* (2019) recorded highest gross returns, net returns and B:C ratio with application of 100% RDF in finger millet on clay loam soils of Garhwal, Uttarakhand.

Higher net returns and benefit-cost ratio were realized with application of 100% RDF (30:15:15 kg/ha NPK) in foxtail millet compared to application of 75% RDF on medium black soils at Raichur, Karnataka during *kharif* (Mubeena *et al.* 2019).

Buduri *et al.* (2020) conducted an experiment during the *kharif* season 2019, at SHUATS, Prayagraj on pearl millet. They reported that the higher gross return, net return and benefit: cost ratio (BCR) were reported with the application of 75:40:40 kg/ha NPK.

12.2 Effect of plant growth regulators

12.2.1 Growth attributes

Muthukumar *et al.* (2005) documented that spraying NAA at 40 ppm at 15 and 30 DAS in baby corn gave maximum values of LAI, plant height and dry matter accumulation over mepiquat chloride @ 200 ppm and water spray at 45 DAS and harvest.

Djanaguiraman and Ramesh (2013) observed that treatment of plant growth regulating chemicals such as NAA at 40 ppm and salicylic acid at 200 ppm at boot leaf stage in sweet sorghum increased plant height and stem diameter. The increments over control followed the order NAA at 40 ppm followed by salicylic acid at 200 ppm.

Manzoor *et al.* (2015) at Rawalpindi (Pakistan) under drought and salt stressed conditions evaluated the effect of various levels of salicylic acid on physiological and biochemical changes in maize and observed that foliar spray of SA at 0.5 mM concentration substantially increased the chlorophyll content in plants. It was concluded that salicylic acid at lower concentration was more effective in minimizing the effect of stress conditions than higher concentrations.

Ahmad *et al.* (2018) at Peshawar (Pakistan) revealed that substantial effect on grain yield of maize with the use of salicylic acid at 300 mg/L.

Ahmadizadeh *et al.* (2018) at Kerman (Iraq) under drought condition found positive effect of salicylic acid application @ 2 mM in sorghum on plant height, forage yield, chlorophyll content (SPAD), 1000-grain weight, biological yield and grain yield.

Jangra (2019) at Hisar studied the physiological response of sorghum to leaf spray of salicylic acid under salt stress conditions. Leaf spray of salicylic acid@ 50 mg/L had significant better effect on crop plants than SA @ 25 mg/L. Growth parameters such as plant height (cm), fresh and dry weight (g), leaf area (cm^2) and leaf number increased from 19.53 to 27.48, 11.36 to 15.65, 1.12 to 1.80, 50 to 78 and 4 to 5, respectively, over control.

Odib *et al.* (2020) experimented on oat at Baghdad University through application of different doses of salicylic acid (100, 200 and 300 ppm) at four growth stages (tillering, elongation, booting and heading stage). Spraying salicylic acid @ 100 ppm at tillering stage recorded higher area of flag leaf, plant height, number of tillers and plant dry weight than control.

Hussain *et al.* (2021) observed higher leaves/plant, leaf area, chlorophyll content compared to control in hybrid sorghum with spraying of NAA at120 mL/ha at booting stage (45 DAS).

Dehnavi *et al.* (2022) conducted a pot experiment in clay-loam soil at Isfahan (Iran) to assess the impact of salicylic acid application on salt stressed sorghum. The result revealed that foliar application of salicylic acid in saline condition promoted an adaptive response to salinity and relieved salt toxicity. Under saline situations, leaf spray of salicylic acid at 150 mg/L was found to be the most effective in alleviating the adverse impacts of salt stress on sorghum plants whereas, application of SA at 100 mg/L was effective in non-saline conditions for enhancing growth and dry matter output of sorghum.

12.2.2 Yield attributes and yield

Bayat and Sepehri (2012) at Hamedan (Iran) reported that external application of SA at 0.5 mM concentration had marked influence on vegetative growth indices of maize plant under various irrigation regimes. Combined effects of salicylic acid and 100, 70, 40 % of full irrigation significantly enhanced the grain yield by 15.85, 20.81, 29.74 % and biological yield by 15.41, 19.38 and 23.19 %, respectively, compared to untreated plots.

Djanaguiraman and Ramesh (2013) reported that spraying plant growth regulating chemicals like naphthalene acetic acid @ 40 ppm and salicylic acid @ 200 ppm in sweet sorghum at boot leaf stage gave higher stalk yield and theoretical ethanol yield with NAA @ 40 ppm and seed yield with salicylic acid @ 200 than control. NAA @ 40 ppm was found effective than salicylic acid.

Waqas *et al.* (2017) documented that applying SA on hybrid maize canopy induced the chilling tolerance and SA @ 0.1% given at six leaf stage and tasselling stage produced

higher grains in a cob,1000-grain weight, grain yield and biological yield than control and water spray.

Satishkumar *et al.* (2018) documented that spraying 40 ppm of salicylic acid in finger millet at pre-flowering and post-flowering stage produced higher panicles/hill, productive tillers/m^2, panicle weight, straw yield and seed yield than control.

Odib *et al.* (2020) found that leaf spray of SA @ 100 ppm given at starting of vegetative phase registered the maximum number of grains in each panicle, 1000-grain mass, grain and straw yield in oat compared to the others concentration (0, 200 and 300 ppm) at four growth stages.

Hussain *et al.* (2021) documented that foliar spraying of NAA at120 mL/ha given at booting stage (45 DAS) in hybrid sorghum recorded higher fodder yield than control.

12.2.3 Quality

Amin *et al.* (2013) at Egypt investigated the response of some metabolic constituents of maize in relation to foliar spray of salicylic acid (100, 200 and 400 mg/L)and thiourea (500, 1000 and1500 mg/L)and reported that foliar application of either salicylic acid or thiourea at any concentration alone or in combination significantly improved the crude protein content, total carbohydrates in the grains, TSS and total free amino acids in leaves.

Saedpanah *et al.* (2016) observed that foliar spray of salicylic acid (2%) in maize yield maximum crude protein than ascorbic acid (2%) and control.

Waqas *et al.* (2017) documented that spraying of salicylic acid @ 0.1% at the six-leaf stage and tasselling stage induced the chilling tolerance in hybrid maize and further it enhanced quality parameters such as protein content in grain, starch content than control and water spray treatments.

Salem (2020) at Egypt reported that utilization of salicylic acid significantly improved protein content and protein yield of pearl millet. Soaking of pearl millet grains in 200 mg/L salicylic acid treatment was the best practice. Boron application also had significant effect on above mentioned characters.

12.2.4 Nutrient content and uptake

Golada *et al.* (2017) reported higher nitrogen content and uptake by green fodder was found with the treatment of naphthalene acetic acid @ 40 ppm at 25 and 35 days after sowing in baby corn than control and mepiquat chloride @ 200 ppm.

12.2.5 Economics

Waqas *et al.* (2017) disclosed that spraying of salicylic acid @ 0.1% in hybrid maize at six leaf stage and tasselling stage produced higher gross return, net return and benefit-cost ratio over control and water spray.

Hussain *et al.* (2021) reported that applying 120 mL/ha of NAA on hybrid sorghum at the booting stage produced the highest total returns, net profit and BCR over NAA at 0, 40, 80 and 160 mL/ha.

12.3 Effect of NPK with plant growth regulators

12.3.1 Growth attributes

Suresh *et al.* (2020) investigation an experiment at Tamil Nadu on pearl millet and recorded significantly higher productive tiller/plant, earhead length and earhead grith by the treatment 125% RDF + foliar application of NAA @40 ppm at 20 and 40 days after sowing.

Rao *et al.* (2021) identified an experiment during *rabi* at Andhra Pradesh on baby corn and reported significantly improved plant height (177.60 cm), number of leaves (11.33), plant dry weight (113.58g/plant), chlorophyll content (68.43) and leaf area index (8.65) with combination of three levels of nitrogen (60, 90 and 120 kg/ha) and three levels of NAA (20, 40 and 60 ppm) at 25 and 35 DAS.

Snehdeep *et al.* (2025) noted an experiment at Prayagraj on pearl millet and results show significantly higher plant height (130.66 cm), plant dry weight (56.23 g), number of earheads/m^2 (26.33) with application of phosphorus 80 kg/ha + NAA 40 ppm.

12.3.2 Yield attributes and yield

Shalaby *et al.* (2017) studied the effect of salicylic acid and NPK fertilization on wheat productivity during seasons. The results show that in both seasons studied parameter were responded significantly by NPK fertilization at higher rates 125, 45 and 48 kg/fed of N, P_2O_5 and K_2O, respectively and SA concentration (150 ppm). Additionally, wheat plants exposed to NPK fertilizers at higher rate and sprayed with high salicylic acid concentration produced the highest mean values of grain yield 2600 and 2520 kg/fed in the first and second seasons, respectively.

Noori *et al.* (2018) studied the effect of combined use of potassium (K) and SA on yield and grain quality of wheat under drought stress. Results showed that application of combined SA and high K levels increased grain yield (13.3%), water-soluble pentosan content (20.3%) and starch (12.2%) when compared to SA-untreated with low level of K fertilizer. In addition to that, SA application decreased the percentage of phytate

phosphorus to total phosphorus under drought stress. Under mild drought conditions it showed a decrease in grain yield by 41.1%, water-soluble pentosan content by 3.5% and starch content by 10.2% in comparison to well-irrigated control.

Suresh *et al.* (2020) conducted an experiment at Tamil Nadu on pearl millet and found significantly higher grain yield (3310 kg/ha) with application of 125% RDF + foliar application of NAA @40 ppm at 20 and 40 days after sowing.

Rao *et al.* (2021) documented an experiment during *rabi* at Andhra Pradesh on baby corn and reported significantly improved green fodder yield (20333 kg/ha) with combination of three levels of nitrogen (60, 90 and 120 kg/ha) and three levels of NAA (20, 40 and 60 ppm) at 25 and 35 DAS.

Snehdeep *et al.* (2025) performed an experiment at Prayagraj on pearl millet and reported significantly maximum grain yield (3.56 t/ha) and stover yield (5.97 t/ha) with application of phosphorus 80 kg/ha + NAA 40 ppm.

12.3.3 Quality

Suresh *et al.* (2020) conducted an experiment at Tamil Nadu on pearl millet and reported significantly higher protein content (12.64 %) with use of 125% RDF + foliar application of NAA @40 ppm at 20 and 40 days after sowing.

12.3.4 Nutrient content and uptake

Adam et al. (2020) carried out a study in Bangladesh on wheat and observed that soaking seeds in 10 ppm NAA combined with 75% nitrogen fertilizer (SOF_3) resulted in significantly higher NPK uptake in both shoots and roots at different sowing times. However, during the grain filling stage, the maximum uptake of NPK by shoots and roots, along with higher nitrogen uptake by roots, was recorded with seed treatment of 10 ppm NAA along with 100% nitrogen fertilizer (SOF_4), followed by the SOF_3 treatment.

12.3.5 Economics

Rao *et al.* (2021) completed an experiment during *rabi* at Andhra Pradesh on baby corn and recorded that highest net returns (₹83,701.88/ha) and Benefit: Cost ratio (1.68) with combination of three different levels of nitrogen (60, 90 and 120 kg/ha) and three different levels of NAA (20, 40 and 60 ppm) at 25 and 35 DAS.

13. Materials and Methods

13.1	**Location**	:	Instructional Farm, Department of Agronomy, College of Agriculture, JAU, Junagadh
13.2	**Year and season of experiment**	:	Summer-2026 & 2027
13.3	**Experimental design**	:	Randomised block design (RBD)

13.4 Experimental details

1.	**Title of the Experiment**	:	Effect of plant growth regulators and fertilizer levels on growth, yield and quality of summer pearl millet
2.	**Number of treatments**	:	10 (Ten)
3.	**Spacing**	:	60 x10 cm
4.	**Crop and Variety**	:	Pearl millet, GHB 1231
5.	**Seed rate**	:	4.0 kg/ha
6.	**Plot size**	:	Gross: 5.0 m x 3.6 m Net: 4.0 m x 2.4 m
7.	**Recommended dose of fertilizers**	:	120:60:00 N: P_2O_5: K_2O kg/ha

13.5 Treatment details

T. No.	Treatment Details
T_1	Control
T_2	100% RDF (120:60:00 NPK kg/ha)
T_3	60% RDF + NAA 40 ppm at 45 DAS
T_4	60% RDF + Salicylic acid 150 ppm at 45 DAS
T_5	75% RDF + NAA 40 ppm at 45 DAS
T_6	75% RDF + Salicylic acid 150 ppm at 45 DAS
T_7	80% RDF + NAA 40 ppm at 45 DAS
T_8	80% RDF + Salicylic acid 150 ppm at 45 DAS
T_9	Sole spray of NAA 40 ppm at 45 DAS
T_{10}	Sole spray of Salicylic acid 150 ppm at 45 DAS

13.6 Number of replications: 03 (Three)

13.7 Observation to be recorded

13.7.1 Growth, yield attributes and yield

13.7.1.1 Growth parameters

1. Plant population at 20 days after sowing and at harvest
2. Plant height (cm) at 45 days after sowing and at harvest
3. Dry matter accumulation (g/plant) at 30, 60 days after sowing and at harvest
4. Total chlorophyll content at 45 DAS
5. Leaf area index
6. Leaf area ratio
7. Crop growth rate
8. Relative growth rate

13.7.1.2 Yield attributes and Yield

1. No. of effective tillers per plant
2. Ear head length (cm)
3. Ear head girth (cm)
4. Test weight (g)
5. Grain yield (kg/ha)
6. Stover yield (kg/ha)
7. Biological yield (kg/ha)
8. Harvest index (%)

13.7.1.3 Quality parameter

1. Protein content (%)
2. Protein yield (kg/ha)

13.7.1.4 Nutrient content and uptake

1. N, P, K content (%) in seed and stover
2. N, P, K uptake (kg/ha) by seed and stover

Table 1: Details of methods for the estimation of nutrients in seed and stover

Nutrients	Method	Reference
Nitrogen	Micro Kjeldahl's method	Kanwar and Chopra (1967)
Phosphorus	Vando-molybdo phosphoric acid yellow colour method	Jackson (1974)
Potassium	Flame Photometer method	Jackson (1974)

13.7.1.5 Economics

1. Cost of cultivation (₹/ha)

The expenses incurred for all the cultivation operations from preparatory tillage to harvesting including the cost of inputs *viz*., seeds, fertilizers, herbicides, pesticides, *etc*. applied to treatments will be calculated on the basis of prevailing local charges.

2. Gross return (₹/ha)

The gross realization in terms of rupees per hectare will be worked out taking into consideration the seed and leaf yields from each treatment and local market prices.

3. Net returns (₹/ha)

Net returns of each treatment will be calculated by deducting the total cost of cultivation from the gross returns.

4. B: C ratio

The benefit cost ratio will be calculated with the help of following formula

$$\text{B: C ratio} = \frac{\text{Gross return((₹/ha)}}{\text{Total cost of cultivation (₹/ha)}}$$

13.7.1.6 Chemical analysis

1. Available N, P_2O_5 and K_2O in the soil before sowing and after harvest of the crop.

Table 2: Detail of methods for the estimation of nutrients in soil

Nutrients	Method	Reference
Available Nitrogen	Alkaline permanganate method	Subbiah and Asija (1956)
Available Phosphorus	Olsen's method	Olsen *et al*. (1954)
Available Potassium	Flame photometric method	Jackson (1974)

14. Statistical Analysis

The data will be subjected to statistical analysis by adopting appropriate analysis of variance as described by Gomez and Gomez (1984). Wherever the F values found significant at 5% level of probability, the critical difference (CD) values/DNMRT will be computed for making comparison among the treatment means. In order to establish interrelationship between various components, coefficients of correlation and regression equations will be computed as described by Panse and Sukhatme (1985).

15. References

Adam, A. G., Jahan, N. and Rashid, P. (2020). Effects of NAA and nitrogen fertilizer on NPK uptake and nitrogen use efficiency of BARI gom-25 (*Triticum aestivum* L.). *Bangladesh Journal of Botany,* **49**(3):643–651.

Ahmad, W., Tahir, M., Ahmad, R. and Ahmad, R. (2018). Agronomic biofortification of fodder sorghum with zinc under different levels of nitrogen. *Sains Malaysiana,* **47**(6):1269-1276.

Ahmadizadeh, A., Khajoei-Nejad, G. and Abdoshahi, R. (2018). Effect of salicylic acid on morphological characteristics and yield of sorghum (*Sorghum bicolor* L.) cultivars under different irrigation regimes. *Cereal Research,* **7**(4):591-603.

Amin, A. A., El-Kader, A, A., Shalaby, M, A., Gharib, F, A., Rashad, E., S., M. and Teixeira da Silva, J., A. (2013). Physiological effects of salicylic acid and thiourea on growth and productivity of maize plants in sandy soil. *Communications in soil science and plant analysis,* **44**(7):1141-1155.

Anonymous. (2025). Agricultural Statistics at a Glance, Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics & Statistics, Government of India Publication, New Delhi, India.

Azam, M., Ejaz, A. W., Asim P. and Nawaz, F. (2010). Response of a newly developed fodder sorghum (*Sorghum Bicolor* L.) variety (F-9917) to NPK application. *Pakistan Journal Life and Social Science,* **8**(2): 117-120.

Bayat, S. and Sepehri, A. (2012). Paclobutrazol and salicylic acid application ameliorates the negative effect of water stress on growth and yield of maize plants. *Journal of Research in Agricultural Science,* **8**(2):127-139.

Bekele, M., Teressa, T. and Amsalu, B. (2021). Effect of foliar application time and rates of exogenous salicylic acid on growth and grain yield performances of sorghum [*Sorghum bicolor* (L.) Moench]. *International Journal of Agricultural and Applied Sciences,* **2**(2): 126-137.

Buduri, B., Marri, P. and Joy, D. (2020). Effect of levels of nitrogen and potassium on growth and yield of rainfed pearl millet (*Pennisetum glaucum* L.). *International Journal of Current Microbiology and Applied Sciences*, **9**(11): 2319-7706.

Chouhan, M., Gudhadhe, N. N., Kumar, D., Kumawat, A. K. and Kumar, R. (2015). Transplanting dates and nitrogen levels influences on growth, yield attributes,

and yield of summer pearl millet. *International Quarterly Journal of Life Sciences,* **10**(3): 1295-1298.

Dehnavi, A., Zahedi, M., Ludwiczak, A. and Piernik, A. (2022). Foliar application of salicylic acid improves salt tolerance of sorghum [*Sorghum bicolor* (L.) Moench]. *Plants Basel,* **11**(3):368.

Deshmukh, A.R., Sarode, M. D. and Deshmukh, A. N. (2019). Effect of potassium on soil fertility, yield and quality of pearl millet (*Pennisetum glaucum* L.) in inceptisol. *Journal of Pharmacognosy and Phytochemistry,* **8**(6):1731-1734.

Divyashree, U., Kumar, D. M., Sridhara, Sand. and Naik, T. B. (2018). Effect of different levels of fertilizers on growth and yield of little millet (*Panicum sumatrense Rothex Roemand Schult*). *International Journal of Farm Sciences*, **8**(2):104-108.

Djanaguiraman, M. and Ramesh, D. (2013). Increasing millable cane yield of sweet sorghum altered nitrogen, population level and plant growth regulators spray. *Journal of Crop Production,* **2**(1):08-18.

Golada, S. L., Sharma, G. L. and Nepalia, V. (2017). Effect of spacing, nitrogen and growth regulators on yield and nutrient uptake by baby corn (*Zea mays* L.). *Annals of Plant and Soil Research,* **19**(2):148-153.

Gomez, K. A. and Gomez, A. A. (1984). *Statistical Procedures for Agricultural Research*. John wiley and sons, Phillippines.

Harika, J. V., Maitra, S., Shankar, T., Bera, M. and Manasa, P. (2019). Effect of integrated nutrient management on productivity, nutrient uptake and economics of finger millet (*Eleusine coracana* L. Gaertn). *International Journal of Agriculture, Environment and Biotechnology,* **12**(3):273 279.

Hussain, I., Ali, M., Bakhsh, I. and Malik, M. W. I. (2021). Effect of different levels of naphthalene acetic acid at various phenological stages of hybrid sorghum to enhance fodder productivity. *Pakistan Journal of Agricultural Research,* **34**(1):121-127.

Jackson, M. L. (1974). *Soil Chemical Analysis*. Printice Hall of India Pvt. Ltd., New Delhi, Pp. 327-350.

Jakhar, R. R., Shekhawat, P. S., Yadav, R. S., Kumawat, A. and Singh, S. P. (2018). Integrated nutrient management in pearl millet (*Pennisetum glaucum*) in north-western Rajasthan. *Indian Journal of Agronomy,* **63**(2):192-196.

Janda. T., Pal, M., Darko, E. and Szalai, G. (2017). Use of salicylic acid and related compounds to improve the abiotic stress tolerance of plants practical aspects. In Salicylic acid a multifaceted hormone. *Springer Singapore,* **2**:35-46.

Jangra, M. (2019). Effect of salicylic acid on growth and plant water status of sorghum genotype under salt stress. *International Journal of Chemical Studies,* **7**(2):1180-1184.

Jat, M. K., Purohit, H. S. and Singh, P. (2014). Effect of farm yard manure, fertility levels and bio-fertilizers on growth, yield and quality of sorghum. *Research on Crops,* **15**(1):78-83.

Jat, R. L., Sharlla, P. and Chaudhari, A. C. (2002). Effect of nitrogen and sulphur on yield and quality of pearl millet (*Pennisetuin glaucum*). *Annals ofAgricultura1 Research,* **23**(2): 226-228.

Kanwar, J. S. and Chopra, S. L. (1967). *Analytical Agricultural Chemistry*. Kalyani Publishers, New Delhi, pp. 518.

Khambalkar, P. A., Tomar, P. S. and Verma, S. K. (2012). Long-term effects of integrated nutrient management on productivity and soil fertility in pearl millet (*Pennisetum glaucum*) – mustard (*Brassica juncea*) cropping sequence. *Indian Journal of Agronomy,* **57**(3): 222-228.

Kumar, A., Paliwal, A., Rawat, L., Kumar, P. and Chaudhary, S. (2019). Performance of high yielding varieties of fingermillet [*Eleusine coracana* (L.) Gaertn] under different fertility level in Garhwal region of Uttarakhand. *Journal of Pharmacognosy and Phytochemistry,* **8**(2):1260-1261.

Kumar, P., Singh, R., Singh, A., Paliwal, D. and Kumar, S. (2014). Integrated nutrient management in pearl millet (*Pennisetum glaucum*)-wheat (*Triticum aestivum*) cropping sequence in semi-arid condition of India. *International Journal of Agricultural Sciences,* **10**(1): 96-101.

Kumar, V. P., Srivastsava, K. P., Sankar, G. M. and Singh, S. P. (2015). Effect of organic and inorganic fertilizers on soil and plant nutrients and yield of pearl millet and wheat under semi-arid inceptisols in India. *Communications in Soil Science and Plant Analysis,* **46**(20):150922085046003

Manzoor, M. (2015). Effect of salicylic acid on physiological and biochemical changes in maize under drought and salt stress conditions. *Journal of Agricultural Science,* **7**(3):113–125.

Mourya, A. and Singh, S. (2022). Effect of Bio-fertilizers and plant growth regulators on growth and yield of pearl millet (*Pennisetum glaucum* L.). *The Pharma Innovation,* **11**(4):1,791-1,794.

Mubeena, P., Halepyati, A. Sand. and Chittapur, B. M. (2019). Effect of date of sowing and nutrient management on nutrient uptake and yield of foxtail millet (*Setaria italica* L.). *International Journal of Bio-resource and Stress Management,* **10**(1):092-095.

Muthukumar, V. B., Velayudham, K. and Thavaprakaash, N. (2005). Growth and yield of baby corn (*Zea mays* L.) as influenced by plant growth regulators and different time of nitrogen application. *Research Journal of Agriculture and Biological Sciences,***1**(4): 303-307.

Noori, Safar, M., Assaha, D. V. M. and Saneoka, L. H. (2018). Effect of Salicylic acid and potassium application on yield and grain nutritional quality of wheat under drought stress condition. *Cereal Research Communications,* **46**(3):558–568.

Odib, R. K. and Dahal, E. N. (2020). Evaluation of the biological response of the salicylic acid on growth and yield of oat. *Plant Archives,* **20**(1):1563-1569.

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture in cooperation with the Colorado Agricultural Experiment Station, pp. 939.

Panse, V. G. and Sukhatme, P. V. (1985). *Statistical Methods for Agricultural Research*. ICAR, New Delhi, **8**:308-318.

Parihar, C. M., Rana, K. S. and Parihar, M. D. (2009). Crop productivity and nutrient uptake of pearl millet (*Pennisetum glaucum*) Indian mustard (*Brassica juncea*) cropping system as influenced by land configuration and direct and residual effect of nutrient management. *Indian Journal of Agricultural Sciences,***79**(11): 927-930.

Patil, S. V., Bhosale, A. S. and Khambal, P. D. (2015). Effect of various levels of fertilizers on growth and yield of fingermillet. *Journal of Agriculture and Veterinary Science,* **8**(6):49-52.

Raj, M. and Sangwan, P. S. (2003). Integrated nutrient management pearl millet-pearl millet cropping sequence under dry land conditions. *Indian Journal of Dryland Agriculture Research and Development,* **18**:103-106.

Ramya, P., Maitra, S., Shankar, T., Adhikary, R. and Palai, J. B. (2020). Growth and productivity of finger millet (*Eleusine coracana* L. Gaertn) as influenced by integrated nutrient management. *Journal of Agricultural Economics,***7**(2):19-24.

Rao, K. S., Singh, S., Chandra, K, R. and Joy, D. (2021). Effect of nitrogen and foliar application of naphthalene acetic acid (NAA) on growth and yield of baby corn (*Zea mays* L.). *International Journal of Plant and Soil Science,* **33**(22):55-61.

Rathore, V. S., Singh, P. and Gautam, R. C. (2006). Productivity and water use efficiency of rainfed pearl millet (*Pennisetum glaucum* L.) as influenced by planting patterns and integrated nutrient management. *Indian Journal of Agronomy,* **51**(1):46-48.

Reddy, S. B. P., Madhuri, K. V., Venkaiah, K. and Prathima, T. (2016). Effect of nitrogen and potassium on yield and quality of pearl millet (*Pennisetum glaucum* L.*). International Journal of Agriculture Innovations and Research,* **4**(4): 2319-1473.

Saedpanah, P., Mohammadi, K. and Fayaz, F. (2016). Agronomic traits of forage maize (*Zea mays* L.) in response to spraying of nano fertilizers, ascorbic and salicylic acid. *Journal of Research in Ecology,* **4**(2):359-365.

Sagar, A., Ghosh, G., Singh, V. and Parveem, S. (2017). Effect of different planting methods and nutrient levels on growth, yield and economy of pearl millet (*Pennisetum glaucum* L.). *Journal of Pharmacognosy and Phytochemistry,* 1082-1084.

Salem, E. M. (2020). Cooperative effect of salicylic acid and boron on the productivity of pearl millet crop under the degraded saline soils conditions. *Egyptian Journal of Agronomy,* **42**(2):185-195.

Sarala, N., Kumar, M. H., Madhavilatha, L., Vajantha, B. and Hemalatha, T. (2020). Effect of spacing and fertilizer levels on growth and yield of little millet (*Panicum sumatrense)* in Southern Agro Climatic Zone of Andhra Pradesh. *Andhra Pradesh Journal of Agricultural Sciences,* **69**(2):71-74.

Satishkumar, M. (2018). Effect of salicylic acid on growth and yield of finger millet (*Eleusine coracana* L.). *International Journal of Chemical Studies,* **6**(5):2299-2302.

Shalaby, E. M., Ali, E. A., Abd El-Lattief, E. A. and Asmaa A. Hamdallah. (2017). Effect of salicylic acid foliar spray and NPK fertilization on wheat productivity. *Journal of Agricultural Science,* **48**(5):21-33.

Sharma, H. and Burark S. S. (2015). Bajra price forecasting in chomu market of Jaipur district: An application of SARIMA model. *Agricultural Situation in India,* **71**(11):7-12.

Singh, Nirupma, Singh, S. P., Kumar M., Kanhiya, K. and Kumar, A. (2018). Nutri Cereal Pearl millet: Way Forward. *International Journal of Current Microbiology and Applied Sciences,* **7**(6): 578-581.

Sneh Deep, C., Umesh, Singh, Abhishek. and Singh, Aniket. (2025). Effect of phosphorus and plant growth regulators on growth and yield of pearl millet. *International Journal of Research on Agronomy,* **8**(4):288-291.

Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for estimation of available nitrogen in soils. *Current Science*, **25**: 254-260.

Suresh, Gurrala, Guru, G. and Lokanadhan, Subbalakshmi. (2020). Effect of plant growth regulators and nutrient levels on yield attributes and yield of pearl millet. *Journal of Pharmacognosy and Phytochemistry,* **9**(6):306-311.

Thesiya, N. M., Dobariya, Band, J. and Patel, J. G. (2019). Effect of integrated nutrient management on growth and yield parameters of *kharif* little millet under little millet green gram cropping sequence. *International Journal of Pure and Applied Bioscience,* **7**(3):294-298.

Verma, S., Yadav, R. S., Kumawat, A. and Meena, R. K. (2018). Effect of integrated nutrient management on growth and yield of pearl millet (*Pennisetum glaucum* L.). *International Journal of Current Microbiology and Applied Sciences,* **7**(8):1505–1512.

Vicente, M. R. S. and Plasencia, J. (2011). Salicylic acid beyond defense: its role in plant growth and development. *Journal of Experimental Botany,* **62**(10):3321–3338.

Waqas, M. A., Khan, I., Akhter, M. J., Noor, M. A. and Ashraf, U. (2017). Exogenous application of plant growth regulators (PGRs) induces chilling tolerance in short duration hybrid maize. *Environmental Science and Pollution Research,* **24**(12):11459-11471.

Yadav, R. and Yadav, V. K. (2013). Comparative performance of Indian and Japanese barnyard millet cultivars under varied fertility conditions for dual use in Indian Central Himalayas. *Range Management and Agroforestry,* **34**(2):175-178.

Signature of Student **Signature of Major Guide**

(Manoj Kumar Meena) **(V. B. Bhalu)**

CERTIFICATE

This is to certify that the above mentioned research proposal made by Ph.D. student **MANOJ KUMAR MEENA (Registration No.: 1010125043)** on the topic of "**Effect of plant growth regulators and fertilizer levels on growth, yield and quality of summer pearl millet"** for partial fulfilment of his Doctoral programme in the discipline of **Agronomy** Dated **15/01/2026** has been approved by the Research Advisory Committee during the academic year 2024-25.

Approval of the advisory committee

GUIDE & MEMBERS	NAME	DESIGNATION & ADDRESS	SIGNATURE
Major Guide (Agronomy)	Dr. V. B. Bhalu	Associate Professor Department of Agronomy College of Agriculture JAU, Junagadh	
Minor Guide (Soil Science)	Dr. L. C. Vekaria	Principal Polytechnic in Agriculture Sidsar, JAU, Junagadh	
Member (Agronomy)	Dr. P. K. Chovatia	Professor & Head Department of Agronomy College of Agriculture JAU, Junagadh	
Member (Agronomy)	Dr. S. K. Chhodavadia	Assistant Professor Department of Agronomy College of Agriculture JAU, Junagadh	
Member (Agril. Statistics)	Dr. M. S. Shitap	Assistant Professor Department of Agril. Statistics College of Agriculture JAU, Junagadh	

Recommended by

Signature and Stamp of Major Guide

Signature and Stamp of Professor and Head

Place: Junagadh
Date: /04/2026